

WATER IS CHEAPEST & SAFEST AS A BARRICADE

By Robert D Willcox, Explosive Site Operations Consultant,
PO Box 2448, Warminster, BA12 8YH, UK,
late of CESO(N), MOD Ensleigh, Bath BA1 5AB, UK.

HISTORY

In 1947 the Armament Research Establishment at Fort Halstead UK investigated water as a temporary expedient for the barricading of aerial bombs stored on airfields. Galvanised steel tanks were used to hold the water. The findings in Appendix 1 of their report no. 9/48 are repeated verbatim below.

RETARDATION OF BOMB FRAGMENTS IN WATER

Although the effectiveness of water in reducing the velocity of fragments is widely known, no precise measurements of the retardation coefficients appear to have been made.

The following formula has been based on the underwater results for spheres (Mem de l'Artillerie Francaise 1932 - Tome II, page 573, and Bauer - Annalon dor Physik No. 11 - 1926), on the underwater results for other bodies of regular geometrical shape (supplied by Dr Simmons of the Armament Design Department) and on the relative drag coefficients for fragments of regular shape in air.

Assuming an initial velocity of V_0 feet per second, the distance S in feet of underwater travel from the velocity of a fragment of mass m oz, to be reduced to V feet per second is given by:-

$$\text{Distance (feet)} = 1.75 \log_{10} \frac{V_0}{V} \sqrt[3]{m} \text{ oz.}$$

or in the more usual form:

$$-1.32S / \sqrt[3]{m}$$
$$V = V_0 \cdot e^{-1.32e}$$

This relationship must be regarded as provisional (in the absence of more precise data) and relates to steel fragments of compact shape. i.e. where the length, breadth and thickness are not very different. Thus a 1oz. fragment would fall to 5% of its original velocity in about 2½ feet and for a fragment of elongated shape the reduction in velocity may be even more rapid than that indicated by the formula.

Using the procedure described by Prof. E. N. Mott, F.R.S., in A.O.R.G. Report 138 to determine the mean fragment mass, the following table gives the calculated thickness of water needed to reduce the velocity of the average fragment respectively to 10% and to 5% of its original velocity for several H.E. munitions.

	$\sqrt[3]{m}$ oz.	<u>Thickness of water in ins. to reduce velocity to:</u>	
Bomb H.C. 4000lb.	0.74	15½	20
Bomb M.C. 500lb.	0.8	17	22
Bomb A.S. 250lb.	0.3	6½	8
Shell 9.2 H.E.	0.9	19	24
Shell 4.5 H.E.	0.85	18	23
Shell 3.7 H.E.	0.6	13	16

Report Documentation Page			<i>Form Approved OMB No. 0704-0188</i>		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE AUG 1998	2. REPORT TYPE	3. DATES COVERED 00-00-1998 to 00-00-1998			
4. TITLE AND SUBTITLE Water is Cheapest & Safest as a Barricade		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S)		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Robert D Willcox, Explosive Site Operations Consultant, PO Box 2448, Warminster, BA12 8YH, UK,		8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)			
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM001002. Proceedings of the Twenty-Eighth DoD Explosives Safety Seminar Held in Orlando, FL on 18-20 August 1998.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 5	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Thus the effectiveness of water as traversing material has been long established as has the science to approximate the effective thickness of water according to the parameters of the primary fragments arising from the munition of interest. Note that "compact fragments" are a worst case because non-compact fragments have greater drag so will need less water thickness.

The report covered the detonation of a 4000lb H.C. bomb filled with Minol at Shoeburyness UK at 3.10pm on 17th November 1947. 6ft from it was stood a water filled tank made of mild steel 1/8th of an inch thick, 7.25ft high and 14.25ft long. The detonation was observed by representatives of the Air Ministry, the Ordnance Board and the Explosive Storage and Transport Committee. The tank was made from the prefabricated components of WW2 Emergency Water Supply (EWS) tanks. It was filled with water to a depth of 7ft 2ins. Paragraph 5.1 of the report is reported verbatim:-

5.1 Tank Damage

The four plates forming the side of the tank farther from the bomb were thrown distances from 200 yds. to 300 yds. They had been painted white to facilitate identification. The plates were buckled, and their flanges had been stripped, but there were no fragment strikes or penetrations below the water level in any of these plates. Above the water line there were about seven 'throughs' and seven fragment strikes, all of which were less than $\frac{1}{4}$ inch diameter and which were probably caused by scabs from the near side plates.

The two base plates were recovered from the crater and showed no signs of fragment strike.

The two end plates were recovered at distances of 187 yds. and 214 yds. There were two fragment holes at about 6 ins. from the near edge of one of the end plates where the path length of fragment through the water was of the order of 9 inches.

Pieces of the near side plates were recovered at various distances. All pieces showed an extremely high density of fragmentation.

Clearly the water had worked as a fragment barricade. All the hypersonic fragments had been intercepted. Propagation by fragment attack would have been thwarted. However the flying steel plates from the tanks were a major hazard and it was probably this that consigned the test results to obscurity.

TODAY

Since 1947 plastic has emerged as a water containing material. In an explosion it is far more benign than steel. CESO(N) has tested two different plastic containers, namely moulded rigid polystyrene tanks like those used for domestic fuel oil, and thin polyethene bags. The Navy had a business requirement to build traverses more cheaply, more quickly and with more flexibility in use than the more conventional designs.

CESO(N) trials showed that neither of the plastic materials fly further than the water, i.e. no more than 50 metres, and both methods are entirely effective, the choice between them depending on business and operational considerations. In the UK two manufacturers for these two methods exist. Their products and associated concepts are protected by international patents or patents pending.

The trade name for the rigid tanks is, “Anti-Frag Tanks,”¹ and the thin plastic bag system is called, “Poldine Wall,”² (a pun on polyethene bags and Pendine blocks alias concrete blocks first used as barricades on the Pendine ranges in UK).

The rigid tanks are cylindrical and stand 2.4m high and 1.2m in diameter (8ft x 4ft). Out of each tank a radiussed bite has been taken; i.e. the cross section is a fat crescent. The next tank nestles closely into this bite. A line of these tanks can follow any straight line or curve on the ground. The last tank in a line has no bite. The least thickness of water obtained is 1 metre. The height of water is about 8.1m. A full tank contains 2000 litres (450 gallons). It weighs over two tonnes.

The thin plastic bags are like saddle bags. They are hung either over expanded polystyrene foam blocks or wooden poles suspended by rope. They can be built up into almost any height and width. To intercept vertically launched or lobbed frags they can be made into a roof creating a “Bomb Shelter”. The Bomb Shelter was proved by detonating a 500lb bomb inside and no frags escaped. The blast shock wave released into the environment was 5% of what would have been released from an open detonation.

The operational and business characteristics of the two systems are now described.

The thin plastic bags for the Poldine Wall can be stored flat until required for use. When full they have little resistance to accidental mechanical damage but can be quickly replaced and there is a quick repair method if the original bag is not completely lost. They are very inexpensive. They are not designed to be re-usable, being emptied by slashing with a knife which can be messy although controlled emptying by syphoning is possible. They can be erected on uneven ground. They are very light when empty and easy to position or build by one person with the right water delivery system. They seem best suited to EOD work and field or temporary storage of ammunition. For long term use they will need periodic inspection and maintenance.

The rigid Anti-Frag Tanks have a shelf life of over 20 years. They resist accidental mechanical damage very well. They have a draining cock to which a hose can be fixed, i.e. they are re-usable by design. They require level hardstanding, compacted gravel being sufficient. They are a little heavy when empty and need two or three persons to position them. They are better for long term, permanent storage.

Pictures of the two systems are below.



Plastic saddle bags
on wooden poles.



Poldine Wall.



Poldine Bomb Shelter
(walls and roof).

¹ Made by Plashapes Ltd, Seapatick Rd, Seapatick, Co Down, N Ireland.

² Made by Dell Explosives, Redhall Mill, Colinton Dell, Edinburgh, Scotland.



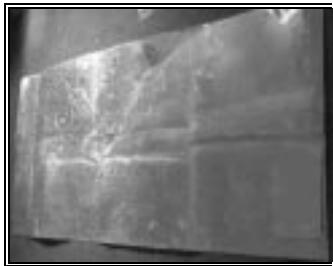
500lb Sea Mine was detonated close to two cars. One was protected by a Poldine Wall and the other wasn't. Afterwards the protected car was driveable and the other was destroyed.



AntiFrag Tanks.



Crater left by detonation of 3 x 1000lb Bombs.



Witness Plates. The one protected by the Tanks shows only the imprint of its concrete block support.

Tank debris close to lip of crater.

CONCLUSIONS

Water Is Safest

The tests of the water barricades showed that all hypersonic steel fragments were intercepted. In addition there was always the bonus of some suppression of the blast shock wave. 95% blast suppression was achieved with the Poldine Bomb Shelter. The blast suppression was general unlike that from solid barricades where blast reduction is due to shock wave refraction and is very local. This bonus makes water safer as a barricade material than solid materials.

Water Is Cheapest

A 30m long vertical face earth barricade was built recently in a Royal Navy depot for over £100,000. Using approximate figures plastic water tanks would have cost 90% less and plastic bags 95% less.

© British Crown Copyright 1998/MOD. Published with the permission of the controller of Her Britannic Majesty's Stationery Office.